Virtual Suit Fit Assessment Using Body Shape Model

Completed Technology Project (2016 - 2016)

Project Introduction

Shoulder injury is one of the most serious risks for crewmembers in long-duration spaceflight. While suboptimal suit fit and contact pressures between the shoulder and suit are identified as risk factors, iterative suit fit assessment processes are prohibitively time consuming and cannot be generalized across wide variations of body shapes and postures.

In this work, we will develop a new design tool based on statistical analysis of a large dataset of crewmember body shape scans. This tool is aimed at predicting the skin deformation and shape variations for any body size and shoulder pose for a target population from which geometry can be exported and evaluated against suit models in commercial CAD software. This new process would enable virtual suit fit assessments, predictively quantifying the contact volume, and clearance between the suit and body surface at reduced time and cost.

Shoulder injury is one of the most severe risks that can impair crewmembers' performance and health in long-duration spaceflight, as evidenced by the high prevalence in extravehicular activity (EVA) and Neutral Buoyancy Laboratory (NBL) training. Overall, 64% of crewmembers experience shoulder pain after extravehicular training in a space suit and 14% of symptomatic crewmembers require surgical repair (Williams & Johnson, 2003).

Suboptimal suit fit, in particular at the shoulder, has been identified as one of the predominant risk factors. However, a traditional suit fit assessment on a test subject provides only a single person's data. Further laser scans may not be generalized across wide variations of body shapes and poses. Iterative testing across the various sizes and poses of crewmembers can be extremely costly and time consuming.

In this work, we propose to develop a software tool based on a statistical analysis of a large dataset of crewmember body shapes. The Anthropometry and Biomechanics Facility at NASA has developed a preliminary computational tool ("baseline model") by statistically processing 150 body shapes matching with Human-Systems Integration Requirements of NASA (MPCV-70024, 2014). Further, the baseline model will be incorporated with shoulder joint articulation ("articulation model"), using additional subjects scanned in a variety of shoulder poses across a predetermined range of motion. Scan data will be cleaned and aligned using body landmarks. The skin deformation patterns will be dimensionally reduced and the co-variation with shoulder angles will be analyzed.

Based on the statistical analysis, we will develop a software tool that predicts the shoulder and upper body geometry as a function of anthropometric measurements and shoulder articulation. The developed tool would allow suit engineers to iteratively generate body shapes in diverse sizes and poses. This tool would also enable virtual fit assessments, with which the contact volume and clearance between the suit and body surface can be predictively quantified

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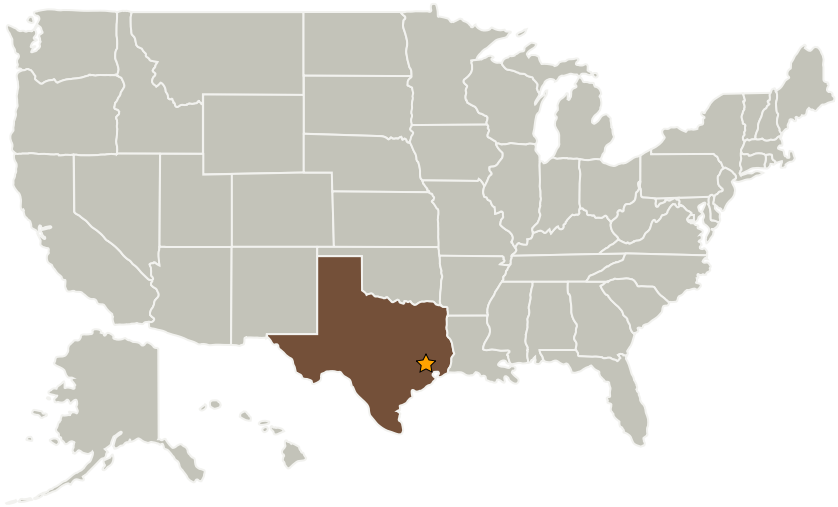
at reduced time and cost.

Anticipated Benefits

Optimal spacesuit design is crucial to minimize the potential injury and health risks for crewmembers in extravehicular and exploration activities. The time and cost has been a prohibitive barrier for comprehensive testing of suit fit. The software tool to be developed in this project can help suit engineers to proactively identify potential issues of suboptimal suit fit at substantially reduced time and cost. The tool can also provide quantitative guidelines for accommodating diverse crewmember populations in a wide variety of body sizes.

Primary U.S. Work Locations and Key Partners



Organizational Responsibility

Responsible Mission Directorate:

Mission Support Directorate (MSD)

Lead Center / Facility:

Johnson Space Center (JSC)

Responsible Program:

Center Independent Research & Development: JSC IRAD

Project Management

Program Manager:

Carlos H Westhelle

Principal Investigator:

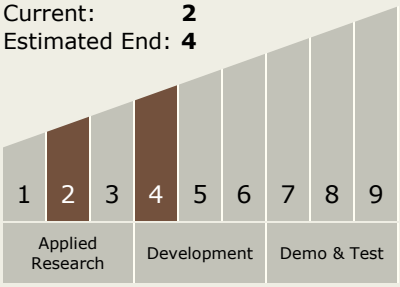
Kyle-han Kim

Co-Investigators:

Sarah Jarvis
Karen Young

Technology Maturity (TRL)

Start: **2**
Current: **2**
Estimated End: **4**



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Organizations Performing Work	Role	Type	Location
★Johnson Space Center(JSC)	Lead Organization	NASA Center	Houston, Texas
Lockheed Martin Inc.	Supporting Organization	Industry	Palo Alto, California
MEI Technologies	Supporting Organization	Industry Small Disadvantaged Business (SDB), Veteran-Owned Small Business (VOSB)	
Wyle Integrated Science and Engineering Group	Supporting Organization	Industry	

Primary U.S. Work Locations
Texas

Technology Areas

Primary:

- TX11 Software, Modeling, Simulation, and Information Processing
  - TX11.2 Modeling
    - TX11.2.3 Human-System Performance Modeling

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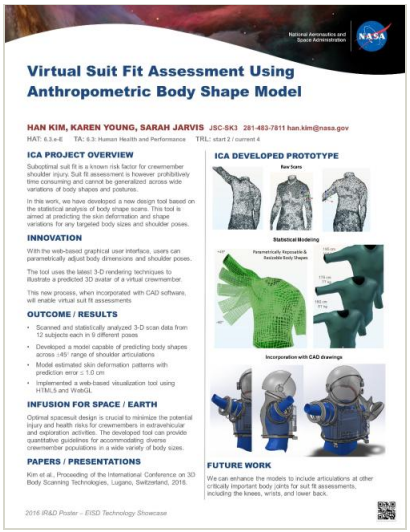
Images



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Virtual Suit Fit Assessment Using Body Shape Model Technology Showcase 2016 Poster *(https://techport.nasa.gov/image/26138)*